1987-03

# Group DSS and decision outcome measures: a comparative study in distributed versus non-distributed settings

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# NAVAL POSTGRADUATE SCHOOL
## Monterey, California


# THESIS

GROUP DSS AND DECISION OUTCOME MEASURES:
A COMPARATIVE STUDY IN DISTRIBUTED
VERSUS NON-DISTRIBUTED SETTINGS

by

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March 1987

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unclassified
SECURITY CLASSIFICATION OF THIS PAGE

# REPORT DOCUMENTATION PAGE

| | |
|---|---|
| 1a REPORT SECURITY CLASSIFICATION: unclassified | 1b RESTRICTIVE MARKINGS |
| 2a SECURITY CLASSIFICATION AUTHORITY | 3 DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution is unlimited. |
| 2b DECLASSIFICATION/DOWNGRADING SCHEDULE | |
| 4 PERFORMING ORGANIZATION REPORT NUMBER(S) | 5 MONITORING ORGANIZATION REPORT NUMBER(S) |
| 6a NAME OF PERFORMING ORGANIZATION: Naval Postgraduate School; 6b OFFICE SYMBOL (If applicable): 54 | 7a NAME OF MONITORING ORGANIZATION: Naval Postgraduate School |
| 6c ADDRESS (City, State, and ZIP Code): Monterey, California 93943-5000 | 7b ADDRESS (City, State, and ZIP Code): Monterey, California 93943-5000 |
| 8a NAME OF FUNDING/SPONSORING ORGANIZATION; 8b OFFICE SYMBOL (If applicable) | 9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER |
| 8c ADDRESS (City, State, and ZIP Code) | 10 SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO; PROJECT NO; TASK NO; WORK UNIT ACCESSION NO |

11 TITLE (Include Security Classification): GROUP DSS AND DECISION OUTCOME MEASURES: A COMPARATIVE STUDY IN DISTRIBUTED VERSUS NON-DISTRIBUTED SETTINGS

12 PERSONAL AUTHOR(S): Fijol, Young-Ok and Woodbury, Mary A.

| 13a TYPE OF REPORT | 13b TIME COVERED | 14 DATE OF REPORT (Year, Month, Day) | 15 PAGE COUNT |
|---|---|---|---|
| Master's Thesis | FROM ____ TO ____ | 1987 March | 53 |

16 SUPPLEMENTARY NOTATION

| 17 COSATI CODES | | | 18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number) |
|---|---|---|---|
| FIELD | GROUP | SUB-GROUP | GDSS, distributed versus non-distributed setting, computer-mediated problem-solving |
| | | | |
| | | | |

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

The recent advancements in the communication and computer technologies, combined with the proliferation of powerful and inexpensive microcomputers, are generating strong interests in the application of group decision support systems (GDSS) on group decision-making and problem solving activities. This thesis is an experimental study on the relative effectiveness and efficiency of one such system, Co-oP, in distributed versus non-distributed decision-making settings. The decision task performance variables tested were the decision outcome measures of decision quality, decision speed, and satisfaction with the results. The analysis of the data indicate that better decision quality and decision speed were achieved in the distributed mode. No difference in satisfaction levels between the two groups were substantiated.

| 20 DISTRIBUTION/AVAILABILITY OF ABSTRACT | 21 ABSTRACT SECURITY CLASSIFICATION | |
|---|---|---|
| ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS | unclassified | |
| 22a NAME OF RESPONSIBLE INDIVIDUAL: Prof. Tung X. Bui | 22b TELEPHONE (Include Area Code): (408) 646-2630 | 22c OFFICE SYMBOL: Code 54Bd |

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted; All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE
unclassified

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# Group DSS and Decision Outcome Measures: A Comparative Study in Distributed Versus Non-Distributed Settings

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MASTER OF SCIENCE IN INFORMATION SYSTEMS

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NAVAL POSTGRADUATE SCHOOL
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## ABSTRACT

The recent advancements in the communication and computer technologies, combined with the proliferation of powerful and inexpensive microcomputers, are generating strong interests in the application of group decision support systems (GDSS) on group decision-making and problem solving activities. This thesis is an experimental study on the relative effectiveness and efficiency of one such system, Co-oP, in distributed versus non-distributed decision-making settings. The decision task performance variables tested were the decision outcome measures of decision quality, decision speed, and satisfaction with the results. The analysis of the data indicate that better decision quality and decision speed were achieved in the distributed mode. No difference in satisfaction levels between the two groups were substantiated.

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# I. INTRODUCTION

Rapid advancements in the communication and computer technologies coupled with today's need to deal with more complex and numerous decision making situations will most likely result in the widespread adoption and utilization of computer-mediated communication systems in the coming years. It is, therefore, important to understand the impact of these systems on decision making processes and, particularly, the differences between computer-mediated and face-to-face interactions, so that the systems may be implemented for most effective and efficient use.

Some of the more frequently expressed comments regarding the differences between computer-mediated and face-to-face interactions are:

- computerized mediation diminishes the social impact [Refs. 1,2],
- managers are action-oriented and prefer face-to-face communications, [Refs. 3,4], and
- use of computer mediated systems may result in the lessening of interpersonal relationships and a loss of the richness of human interaction.

On the other hand, computer-mediated systems, especially those that support distributed decision making, can encourage individual participation and increase the speed of communication. Turoff and Hiltz also observe after testing the differences between face-to-face and computer-mediated systems (distributed decision support systems):

> the nature of communication in computerized conferences devoted to decision making tends to be oriented more towards the achievement of quality decision and less toward the social-emotion types of communications which aid consensus, compared to face-to-face conferences. [Ref. 5: p. 87]

Other works and concepts on distributed group decision support systems include: distributed decision making (DDM) concept [Refs. 6,7], distributed decision support systems [Ref. 8], computerized conferencing systems [Ref. 5], and distributed group decision support systems [Ref. 9].

At present, no research has firmly established the superiority of one particular concept. Moreover, the context has changed; new technologies and managers' shifting mindset and attitudes toward using computers for decision making may make past assumptions irrelevant.

## A. PURPOSE OF THE STUDY

This study is based on our belief that recent developments in the communication and computer-based information systems, particularly in group decision support systems (GDSS), can increase the efficiency (decision speed) and effectiveness (decision quality) of group decision making and problem solving activities. Decision support tools have developed to the point where they can be applied to these activities. Yet, at the moment, little research exists to substantiate this belief.

Our empirical study is an effort to determine how the use of a GDSS tool would affect the decision outcome variables of distributed groups, where decision makers do not meet face to face, and non-distributed groups, where they interact face to face. The decision outcome variables are such measures as the decision quality, decision speed, and group satisfaction with the decision. The tool is Co-oP, Cooperative Multiple Criteria Decision Making system, designed by Tung X. Bui of the Naval Postgraduate School [Ref. 10].

## B. DECISION MAKING ENVIRONMENT

Today's organizational environment is characterized by increasingly complex and dynamic decision making situations. More than ever before, organizations must be keenly alert to swiftly changing conditions and be prepared to cope with the turbulence generated by these changes. The demands of multiple constituencies, uncertain market opportunities, strong international competitors, increasing legal, social, and environmental constraints, and the growing complexity of the decision tasks all contribute enormously to growing uncertainties in organizations. These uncertainties, in turn, sorely test the organizations' ability to cope with their environment.

The problem is further aggravated by the tremendous amount of information available to organizations. Those within an organization must be able to collect, process, and disseminate relevant information as quickly as possible to avoid being overwhelmed by too much information or missing out on important new developments. The fact that we are presently living in a society in transit to what Bell coined the post-industrial society can only exacerbate this problem [Ref. 11].

Survival in the post-industrial society would force decision makers to make an increasing number of important decisions swiftly and before they have fully grasped and understood the implications of their decisions. Yet, the nature of the organizational environment demands that, most of these decision makers make their

decisions not alone but rather in group meetings or based on group inputs. They rely heavily on the meetings as a way of doing business. In fact, a large share of a manager's time is spent communicating and meeting with peers, supervisors, subordinates, and others inside and outside the organization [Refs. 3,12]. According to various researchers, during a working week middle managers spend approximately 35% of their time in meetings while top managers spend 50% [Ref. 13] or as much as 80% [Ref. 14] in meetings.

## C. PROBLEMS WITH GROUPS

In the years to come, decision makers will face even stronger pressure to participate in an ever increasing number of meetings to facilitate greater and faster exchange of information. Unfortunately, many of these meetings can be long and boring without accomplishing much of anything useful. Due to this awareness and a genuine lack of time, decision makers will find it more and more difficult to get together for all the necessary and required meetings.

The difficulties and frustrations of working in groups are futher aggravated by the inhibiting factors present in the interactive group decision making processes. Van de Ven and Delbecq [Ref. 15: p. 206] summarize the causes that seem to produce inhibiting influences which reduce the performance of interacting groups as follows:

- A "focus effect" wherein interacting groups "fall into a rut" and pursue a single train of thought for long periods.
- The "self-weighing" effect, wherein an individual will participate in the group to the extent that he feels equally competent with others.
- The fact that covert judgments are made but are not expressed as overt criticisms.
- The inevitable presence within most organizational groups of status incongruities, wherein low-status participants may be inhibited and "go along" with opinions expressed by high-status participants, even though they feel their opinions are better.
- Group pressures for conformity and implied threat of sanctions from the more knowledgeable members.
- The influence of dominant personality-types upon the group.
- The amount of time and effort spent by the group to maintain itself. As orientation to maintain group interaction increases, the quality of solutions decreases.
- A tendency to reach "speedy decisions" before all problem dimensions have been considered.

As a result of these inhibiting factors, individuals participating in meetings may not fully utilize their personal knowledge and resources to effectively and efficiently solve the problems at hand.

## D. NEED FOR COMPUTERIZED SUPPORT

Organizations should carefully consider the developments in communication and computer-based information systems that would boost the efficiency and effectiveness of group decision making processes. Huber writes:

> given the apparent need for more decision-group meetings and at the same time a considerable resistance to them, we expect post-industrial organizations to seek and adapt on a widespread basis more sophisticated group technologies, and that as result the effectiveness of decision groups will increase. [Ref. 16: p. 937]

The need for computerized support for organizational decision making has been recognized for some years. However, it is only after two major breakthroughs in the computer-based systems that organizations have been fully able to appreciate the power and utility of computers and their attendant softwares. The two revolutionary developments were: 1) the large variety of user friendly decision support system tools (DSS), such as the database management systems, spreadsheets, and various other decision support software packages that can be readily understood by non-computer experts, and 2) the mass production and commercialization of small, inexpensive microcomputers.

Until recently, the decision support tools have been primarily developed for individual users and not to facilitate groups decision making. However, researchers have now begun to focus on DSSs that will assist the decision makers in group situations. The communication and computer technologies that have been developed so far to make meetings more effective and efficient include: teleconferencing, video-conferencing, electronic mail enhanced Delphi studies [Refs. 17,18], various other computer-mediated communication systems (for a summary of these as well as their associated evaluations, see [Ref. 19]), and group decision support systems. The focus of our study is on the last technology.

# II. GROUP DECISION SUPPORT SYSTEMS

## A. DEFINITION OF THE GDSS

Group decision support systems (GDSS) can be defined quite broadly, depending on the intent of the individual deisigners.

- Bui and Jarke write: "A group DSS can be defined as a computer-based system that aims at supporting collective problem solving." [Ref. 20: p. 82]
- Huber states: "A GDSS consists of a set of software, hardware, and language components and procedures that support a group of people engaged in a decision-related meeting." [Ref. 21: p. 195]
- Turoff and Hiltz (Nominal Group Technique GDSS) suggest that decision support systems (DSS) embedded within computerized conferencing systems can serve as the group decision support system. This can also be referred to as the distributed decision support system. [Ref. 5]
- DeSanctis and Gallupe state: "A group decision support system (GDSS) is an interactive computer-based system which facilitates the solution of unstructured problems by a set of decision makers working together as a group." [Ref. 22: p. 3]

In general, GDSSs are computer-based systems designed to facilitate the interactive sharing and use of information and to assist a group of individuals involved in solving semi-structured and unstructured problems.

## B. CHARACTERISTICS OF THE GDSS

GDSS designers attribute various characteristics to their systems. Some of these are [Ref. 22: p. 4]:

- A GDSS is a specially designed system, not merely a reconfiguration of already existing system components.
- A GDSS is designed with the goal of supporting groups of decision makers in their work.
- A GDSS is easy to learn and easy to use.
- A GDSS may be "specific" (i.e., designed for one type or class of problem) or "general" (i.e., designed for a variety of group level organizational decisions).
- A GDSS contains built-in mechanisms which discourage the development of negative group behaviors.

Most of the GDSSs developed or implemented by the various academic research groups and private industries reflects some or all of the above characteristics.

## C. COMPONENTS OF THE GDSS

The basic components of the GDSSs are hardware, software, people, and procedures. Each of these components will be discussed in detail in the following pages. This discussion is primarily based on the works of Gray [Ref. 23], Turoff and Hiltz [Ref. 5], Huber [Ref. 21], and DeSanctis and Gallupe [Ref. 22].

### 1. Hardware

Basic hardware components should include: a CPU, input/output devices, individual monitors, and/or common viewing screens with graphics capabilities. These should be configured in a manner that will allow individuals to work independently of other group members, publicly show their work, and share inputs with others. More sophisticated systems may include network capabilities, modems, communication lines between a desktop computer and the mainframe, and touch or voice communication devices.

### 2. Software

Generally, GDSS features should include such individual decision support capabilities as database management, model management, specialized application programs, and flexible user interfaces with standard software packages. Some sophisticated systems will also include high-level language capabilities for program writing and interfaces with standard commercial managerial level softwares (graphics, statistical OR packages, spreadsheets, etc.).

Basic GDSS software features are:

- file creation, modification, and storage,
- word processing,
- tutorials,
- on-line help facilities,
- worksheets, spreadsheets, decision trees, and other means of displaying data,
- state-of-the-art database management that would permit ad hoc queries and better control of access to databases. [Ref. 22: p. 5]

The group features, the most distinguishing software component of the GDSS include:

- methods of representing numerically and graphically the various viewpoints of the group members,
- menus which prompt for user inputs,
- programs for aggregating the preferences of the individuals such as voting, ranking, rating, and weighting schemes,
- methods of analyzing prior group interactions and judgments, and

- means of communicating data and text between and among group members. [Ref. 22: p. 4]

3. **People**

This component includes the individuals involved in the decision-making process and possibly a "group facilitator." A facilitator's role can range from being a simple chauffeur, who operates the GDSS hardware and interfaces with the software during the group meetings, to being on call as an advisor when the group experiences difficulties. A facilitator may be physically located within a group member's office, in a data center, or in a MIS department.

4. **Procedures**

Procedures are instructions to the group members and facilitator that explain the use and operation of the system. Depending on the degree of control desired and intent of the designers, procedures may deal only with the use of hardware and software, or may include the specific group decision-making techniques and rules that should be used during group discussions and decision-making processes.

## D. COMMUNICATION COMPONENTS OF THE GDSS

Three major technological components are considered essential in building effective DSSs: the dialogue manager, data manager, and model manager [Ref. 24: p. 195-278]. To this Bui and Jarke add the communication component to expand the DSS into a GDSS [Ref. 20]. The communication component is critical to the success of the GDSS, yet it has often been taken for granted or ignored. The communication manager is utilized in distributed time and/or space settings, as well as in non-distributed settings. In non-distributed setting, communication links provide the group members with the ability to communicate privately to each other, to send information to the public screens, and to access and retrieve information from remote computers as well as access the mainframe from the microcomputers.

In the post-industrial society, the decision-makers will often be geographically and organizationally dispersed and "the diffuseness of influence on decisions will be greater " [Ref. 16: p. 936]. This dispersion and diffuseness, as well as the lack of time, severely restricts the decision-makers' ability to get together for the necessary meetings. For these reasons, any system that qualifies as a GDSS must include the communication component that will support the participants involved in both distributed and non-distributed decision-making settings.

## E. RESEARCH ON GDSS

There are a number of pioneer GDSSs developed or implemented by various academic research groups and private sector corporations. Some of these are described below.

- The Decision Room system at the Southern Methodist University which uses a variety of public display screens and microcomputers. Gray has conducted a series of experiments on this system using MBA students as subjects. [Refs. 23,25]
- Perceptronics, Incorporated uses a decision tree structure called Group Decision Aid. Steeb and Johnston's experimental study used a crisis scenario case developed by the CACI, Inc., and an intermediator facilitator who acted as an intermediary between the system and the group members. [Ref. 26]
- EIES (Electronic Information Exchange System), a computer mediated communication system designed by Turoff. Hiltz and Turoff wrote computerized conferencing systems can be examples of a GDSS in a distributed environment. For a detailed look at the experiments utilizing the EIES and other computer-mediated communication systems, see Turoff and Hiltz [Ref. 5], Hiltz and Turoff [Ref. 18], Kerr and Hiltz [Ref. 19], and Hiltz [Ref. 27].
- Mindsight, developed by Execucom Systems Corporation, was installed using a specially designed U-shaped conference table. The experiment conducted on this system involved senior executives using a case study based on an actual decision-making situation. [Ref. 28]
- Lewis developed, implemented and tested a preliminary version of Facilitator, a microcomputer based decision support system for small groups, at the University of Louisville. Lewis used undergraduate students as subjects and Nominal Group Technique to make a comparison between the groups with a GDSS tool and the groups without the tool. [Ref. 29]
- Gallupe used the modified version of the "Bonanza Business Case", a typical "trouble-shooting" type of problem, on a system built at the University of Minnesota. His experiment also compared the differences between the groups using the system and the groups without the system. [Ref. 30]
- Bui's Co-oP, a Cooperative Multiple Criteria Decision Support System, used in this experiment, is a very specialized GDSS that is still in the process of incorporating other basic GDSS features. [Refs. 9,10]

Although some of these systems have been built and installed/rented at the user locations, most are still being refined to enhance their effectiveness and to make them more commercially feasible.

# III. ISSUES IN GDSS EXPERIMENTAL DESIGN

## A. FRAMEWORK

Gallupe discusses four specific issues that should be carefully considered when conducting an empirical study on the impact of a GDSS [Ref. 30]. Our study is based on the framework of these four issues. These issues are: 1) the nature of the decision task the group must work on, 2) the design of a GDSS, 3) the subjects and the setting, and 4) the dependent variables and their measurement. Each of these will be discussed in detail in this chapter.

## B. GROUP DECISION TASK

One of the major factors affecting group performance is the type of decision task selected for the group to work on [Refs. 31,32,33]. A number of scholars have identified various types of tasks [Refs. 31,34,35,36]. Of particular interest is McGrath's framework of group task, called the Task Circumplex [Refs. 37,38]. The Task Circumplex consists of eight types of tasks: 1) planning, 2) creativity, 3) intellective, 4) decision-making, 5) cognitive conflict, 6) mixed motive, 7) contests/battles/competitive, and 8) performance/psycho-motor tasks.

These tasks can be classified into four processes: generate, choose, negotiate, and execute. See Figure 3.1 for clarification. In the figure, the horizontal axis is composed of conceptual and behavioral dimensions, while the vertical axis consists of conflict and cooperation dimensions.

The focus of our research is on the type 3, intellective tasks, in Quadrant II, the choose process. We selected a case study that required participants, especially those in the non-distributed setting, to be cooperative and come up with the one correct answer.

Gallupe also emphasizes that the group task must possess the following characteristics:

- face validity - the task must appear to be realistic to the participants,
- supportability - the task must lend itself to support by a GDSS,
- content validity - the task description must be accurate and consistent, and
- external validity - the task should be generalizable to actual organizational decision-making situations.

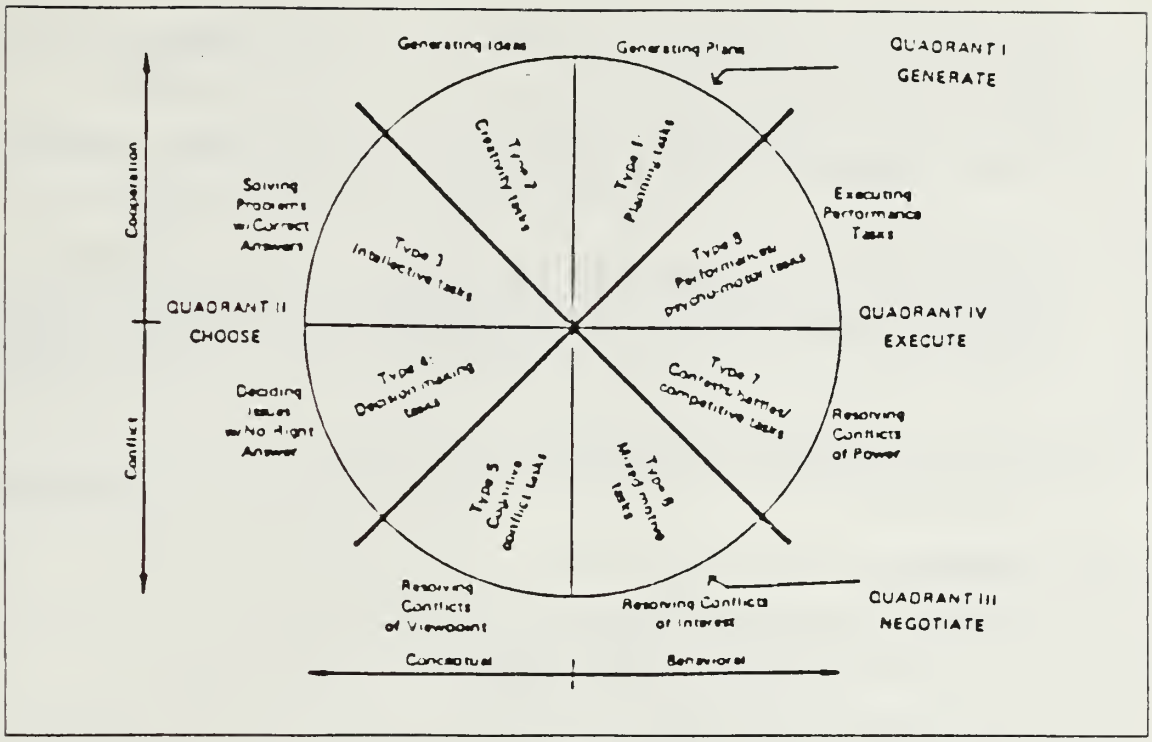



Figure 3.1 Group Task Circumplex.

Each of these characteristics was carefully considered while choosing the case. The validity of each was tested during the questionnaire phase by asking each participant in the experiment to respond to questions pertaining to the specific characteristics described above.

## C. GDSS DESIGN ISSUES

Published works on issues relating to the design of GDSSs include: Huber [Refs. 21,39], Bui [Ref. 10], DeSanctis and Gallupe [Ref. 22], Bui and Jarke [Ref. 9], and Gallupe [Ref. 30]. As mentioned previously, very few GDSSs are commercially available. Those that are available were not designed using universal standards and consist of various hardware configurations with a variety of software features. To conduct research on the impact of GDSSs, researchers are, therefore, faced with two choices: develop their own or adapt an existing system for their experiment.

Before going any further, the researchers must also decide whether to tailor the GDSS to a specific type of group task or whether to develop or adapt a system that could be used for a variety of tasks. Lewis decided on the experimental task first and

then developed the "Facilitator" with features that would support the experimental group in solving the task.

For our experiment, Co-oP, a Cooperative Multiple Criteria Decision-making tool that is designed to facilitate distributed decision making, was used.

> Cooperative group decision-making is a problem solving process in which 1) there are two or more persons, each characterized by his or her own perceptions, attitudes, and personalities, 2) who have recognized the existence of a common problem and 3) attempt to use the system to reach a collective decision. [Ref. 9: p. 86]

Co-oP was not designed for a specific type of task. For detailed works describing Co-oP, see [Refs. 9,10].

## D. SUBJECTS

Gallupe also mentions four concerns regarding subjects:

- the number of subjects and/or group size,
- the background and skills of the subjects,
- the logistics of setting up the experiment, and
- the type of subjects used.

Although a considerable amount of research has been conducted on the influence of group sizes [Refs. 32,40], no published works on optimal group size for effective problem solving using computer and communication technologies are yet available. Past researchers do indicate groups of size five may be optimal for discussion groups; however, there are no indications this may also be applicable to the computer-mediated groups.

Groups composed of three members were chosen for our experiment for the following reasons:

- to facilitate research comparison; previous experiments on the impact of GDSS used groups of size three [Refs. 1,26,29].
- to encourage active participation by all group members in the decision making process, and
- limitations in the number of available subjects.

We were very fortunate in the available subjects. They were all from relatively homogeneous backgrounds with at least five years of managerial experience. For further details, see the section on Subjects in Chapter IV.

## E. SETTING

Selecting the right setting for the experiment is also an important issue. DeSanctis and Gallupe have proposed four scenerios that could be the basis for a number of settings [Ref. 22]. These scenarios are: (1) a "decision room" where the decision makers are in a face-to-face arrangement with or without a computer terminal placed directly in front of each of them; (2) "local decision network" where the group members are in a distributed setting; (3) "teleconferencing" where, basically, two decision rooms are established in separate geographical locations to enable two groups to come together via video and computer conferencing; and (4) "remote decision making" in which geographically dispersed individuals are connected as a group via various communication technologies.

Eventually, the following two scenarios were selected to test the effectiveness of a GDSS tool in distributed versus non-distributed settings with both groups using Co-oP.

Non-distributed: Group members seated around a table with one terminal available to them. Any inputs to the terminal were to be based on group consensus.

Distributed: Group members dispersed in time and space with each member inputting their responses at their convenience.

## F. DEPENDENT VARIABLES AND THEIR MEASUREMENT

The task selected to some degree determines the type of dependent variables that can be measured. Gallupe mentions two types of dependent variables: the "decision outcome measures" and the "decision process measures." The decision outcome measures, which can be more easily measured, are the decision quality, time for groups to reach a decision (decision speed), and group confidence and/or satisfaction with the decision. Of secondary importance, due to imprecise methods of measurement, are the "decision process measures" (i.e., the amount of system usage, the amount ot individual participation by group members, and the number of issues considered).

In a number of research studies, decision quality was measured by comparing the test group's answers against the answers provided by the experts [Refs. 1,5,26,30]. Since the experts' choice was also available with our case, the authors decided to use this as the standard for measuring decision quality.

These four issues: group decision task, design issues, subjects and settings, and variables and their measurements are significant factors in any experimental research on the affect of a GDSS tool on group performance. This chapter discussed these issues and their relevence to our experiment in detail.

For the group decision task, an intellective task, that should be solved in a cooperative atmosphere was chosen. A distributed versus non-distributed setting was selected to best complement the software used. The major variables tested were the three decision outcome measures of decision quality, speed, and satisfaction.

# IV. DESIGN OF AN EXPERIMENTAL STUDY

## A. GROUP DECISION TASK

The Energy International case, which was primarily designed for testing group member interactions, was selected for the experiment [Ref. 41]. The experimental groups' task was to select the most suitable manager for a mining operations in Brazil. The original case, which consisted of five data sheets was consolidated into one page. This was done to expose features of the GDSS which were specifically under consideration, and were in keeping with adaptive variables outlined in the case study itself.

The solution to the task was assumed to be not too intuitively obvious at the outset, but rather required some degree of analysis and comparison of candidate attributes and position requirements. Additionally, to avoid as much as possible any preconceived solutions and inherent biases that could influence subjects' judgment during the input generation phase, the case study was not available to participants prior to actual test time.

The decision task was chosen on the basis of satisfying the essential criteria for a valid case.

### 1. Face Validity

This characteristic implies the task was judged to be realistic to the participants. Since officer-students with managerial background were used as subjects, a case study in management field was chosen. Specifically, the test involved a situation that can be encountered in real life. Sufficient information was provided to participants via a candidate summary sheets to enable them to select the best candidate for the job.

The condition that only one best candidate can be chosen may or may not be realistic. However, for the experiment, this method was proposed in order to compare the experts' choice provided with the case against the results generated by the groups.

### 2. Supportability

Supportability implies the task at hand must lend itself to support by a GDSS. This characteristic was analyzed based on the software used.

- Weights that were assigned to the criteria to select the correct candidate could be shown graphically and numerically.

Both of these representations were used during the experiment. Graphical representations proved useful during the input generation phase, particularly when bargraphs of data just inputed were shown relative to all other inputs. This provided not only a numerical reference, but also visual cues by which members could evaluate their progress and decide whether to proceed or make any changes.

Numerical representations of group members' inputs proved useful in the result analysis phase. Cardinal rankings, ordinal rankings and numerically represented group results provided members with feedback as to how they solved the task both singularly and in relation to other members of their group. This information assisted the members in assessing the decision making strategies employed.

- The case could be best solved by following a series of steps.

This is similar to following a sequence of menus which lead the participant through a series of steps toward the resolution of the task. First, the candidates were listed and then the criteria formulated. Second, weights (between zero and ten) were assigned to each criteria. Finally, each candidate was given specific points (between zero and ten) depending on how well he/she met the criteria. The case selected lent itself well to a weighing scheme as individuals were prompted to develop and weight their own criteria, then vote for candidates according to the system they had devised.

3. **Content Validity**

The case study used was taken directly from a published case, and as such, content was assumed to be valid.

4. **External Validity**

External validity implies the task should appear to belong to a general class of similar tasks and not represent one singularly unique problem. Additionally, the task should appear relevant to the subjects. For this reason, a case that portrays a snapshot of an actual management decision-making situation was chosen.

## B. THE PEOPLE

The following people were involved in the experiment.

1. **Chauffeur**

The chauffeur refers to the system operator who acted as an intermediary between group members and the GDSS software. To avoid unknown parameters and unmeasureable results associated with training subjects in the use of the GDSS, inputs were physically made by a chauffeur. Chauffeur translated verbal commands into

software commands. The presence of a chauffeur or intermediary is well documented in the literature and can be considered an important element in the computer-mediated decision-making process. Also, a chauffer can enhance rather than disrupt the use of the computer based decision support system [Ref. 42].

2. Observer

The observer in this experiment refers to the second experimenter who provided the case study and a questionnaire to individual group members, briefed group members prior to conducting the experiment, noted clock times, and transcribed group input responses to paper as they were simultaneously being entered into the system. The latter was done as a backup measure. Interpretation of software and prompts and or case study elements were not provided by either the chauffeur or observer at any time. Once the experiment began, communications between the observer, chauffeur and any individuals were restricted specifically to the input of data. Likewise, communications between the experimenters were restricted.

3. Subjects

Participants were selected from the officer-student population of the Naval Postgraduate School, primarily from the Computer Systems Management curriculum. Due to the wide-ranging backgrounds of the subjects, no common area of expertise, other than general military management experience, was evident. Each officer-student had a minimum of five years of managerial experience.

Members were in the fifth quarter of a six quarter curriculum. All had been exposed to various management and computer related courses. As such, this relatively homogeneous group of participants, sharing similar management and educational backgrounds, eliminated most of the problems associated with random subject selection. Moreover, members knew one another in a manner suggestive of a corporate environment, where decision makers share a similar culture.

Groups were composed of three members each. There were six groups each in both the interactive and distributed modes, enough to get statistically significant results. Members were encouraged to form their own trios for nondistributed modes. This precluded the necessity for providing introductory sessions, where individual group members could become familiar with one another and with the group decision-making process.

## C. SETTING

No specific decision setting was designed for the experiment. A PC Computer laboratory room in which several IBM PCs and printers were available was used. In this experiment where each member of the distributed group mode was distributed in time and space, access to a networking facility was not necessary. Instead, a chauffeur inserted participants' inputs in a common test disk that was shared with other members of the group. Accountability for disks and disk storage thus became a responsibility of the chauffeur.

### 1. Distributed mode

Group members were tested individually, at a time most convenient for them. Individuals were timed as to read time and input time. Subjects were seated in proximity to the input terminal device and were able to observe their inputs being entered. These inputs were used to form a group result. Domination by any one individual was not possible in this mode.

### 2. Non-distributed mode

Group members were tested as a group. Groups were timed as to read time, discussion time prior to input, and input time. Group members were seated in proximity to the terminal in such a way that all had visual access to the screen. Each person was provided with a complete case study and was free to offer inputs at any time during the input generation phase.

## D. PROCESS

The software utilized for the experiment required establishment of a group norm and problem definition by the chauffeur. This was done prior to presentation of the case to the participants. Selection and/or inclusion of criteria was a discretionary issue, subject to each participant's interpretation of the case and software.

Scheduled groups/individuals were assembled. The observer explained the purpose of the exercise, stressing its significance as a group problem-solving task in a cooperative environment. The following dialogue ensued:

> You are here today to help us test out a Group Decision Support System, namely Co-oP. We are testing this system in two different modes, a distributed mode and a face-to-face mode. In a distributed mode, three members of a group, distributed in time and space input their own individual responses to the system to generate a group result. In a non-distributed mode, three members of a group reach a consensus prior to entering their responses as one input. Our goal is to compare the results from these two modes. The case we have selected is a management-type case; specifically, select the best candidate from a list of candidates for a position described in the case. The case study is one page in

length. Attached to it are the candidate summary sheets. Feel free to write on any sheets provided and take any notes you wish. While reading the case, think about the criteria you yourself would use to select the best candidate. Once you have finished reading the case and feel ready to proceed, so indicate and we will move to the input of criteria phase. Please note, you are restricted by Co-oP to inputting only six major criteria. If you need to generate more, the use of sub-criteria is an option available to you.

Individuals were then asked to read through the case study and candidate summary sheets provided at this time. Questions concerning the task were answered by the chauffeur observer. However, this was the only opportunity participants were given to ask questions.

The observer began timing the problem solving process once the case study had been issued. Time taken to read and absorb the case was considered as well as total input time spent with the chauffeur. The timing of sessions ended once all inputs were assembled.

Group results were provided to non-distributed mode participants immediately following the conclusion of the test. Test results were explained to members as needed, and questionnaires were distributed for completion prior to departure. Group results for distributed mode participants were provided when available and results explained. Questionnaires were distributed for immediate input and retrieval, and returned to subjects for additional inputs comments once the final group result became available.

# V. EXPERIMENTAL STUDY

## A. HYPOTHESES, QUESTIONNAIRE, AND VARIABLES

The authors developed three hypotheses concerning the expected effects of the decision outcome variables on the two groups. The hypotheses are:

- H1: Decision quality will be better in a distributed mode than in a face-to-face (FTF) mode.
- H2: Distributed groups will require less manhours to come up with a group solution.
- H3: There will be no difference in the decision satisfaction level between the two groups.

The authors, as a matter of interest, also sought to find the answers to the following questions:

- Q1: Which group will generate and meet the identified baseline criteria more often?
- Q2: Which group will generate more creative and original criteria?
- Q3: Which group members will be more satisfied with the number of criteria they generated?
- Q4: Do the participants prefer the non-distributed setting or the distributed setting?

The participant questionnaire was used to measure a number of variables. Seventeen questions, which involved selecting a number along a scale that best expressed the subjects' opinions, were asked. Three questions required written responses. Of the seventeen questions, four concerning the case study itself and three dealing with criteria were answered by both groups. Subjects in the distributed groups answered four of the ten remaining questions while the FTF group members answered the rest. The questions were:

Both groups:

1. Immediately after reading the case study, was the correct candidate intuitively obvious to you?
2. Would you say this case study can be an example of an actual decision-making situation in an organization?
3. Does this case study appear to be realistic to you?
4. Does this case study lend itself to support by Co-oP?
5. How satisfied are you with the number of criteria that you identified?
6. Putting weights on your criteria helped you in your decision-making process?
7. To what extent do you feel Co-oP helped you in formalizing your thoughts?

Distributed Group:

8. All in all, how good a solution did you devise?
9. How satisfied are you with the final result derived from your individual inputs?
10. This case is would be better solved in a face-to-face setting vice a distributed setting.
11. How satisfied are you with the group result?

FTF Group:

12. How good a solution did your group devise?
13. How satisfied are you with the decision-making process that your group underwent to develop the solutions?
14. How satisfied are you with the final result derived from your group inputs?
15. Do you feel your group accepted your contributions to solving the problem?
16. Do you think everyone had an equal chance to be heard in your group?
17. This case is would be better solved in a distributed setting vice a face-to-face setting.

Written comments from both groups were elicited by the following:

18. What factor, if any, would you say inhibited and/or encouraged your generation of inputs?
19. Was Co-oP user friendly?
20. In what kind of decision-making situation would you find Co-oP most useful?

The authors wished to measure five variables from the printed summaries of the group inputs and solutions: 1) decision quality, 2) decision speed, 3) number of groups meeting the baseline criteria, 4) number of baseline criteria generated by the groups, and 5) the number of original/creative criteria generated during the group solution process.

The variables to be measured from the questionnaire were: 1) the case selected met the decision task criteria (i. e., face validity, supportability, content validity, and external validity), 2) satisfaction with the final results that the individual/group derived from their inputs, 3) satisfaction with the individual/group solution when compared to the experts' solution, 4) satisfaction with the number of criteria generated, and 5) preference for either FTF or distributed settings.

Where relevant, t-statistic tests were used to test for the mean scores and for the significant differences between the mean scores. For each test, a 0.05 level of significance was used to decide whether or not the null hypothesis (Ho) should be rejected. Null hypotheses were set up where necessary and will be further mentioned as they occur in this chapter. The tail probabilities or p-values (the probabilities of getting a difference between the mean of the sample, x, and the mean of the population from which the sample came, u, is greater than or equal to the ones actually observed) are also included where appropriate. Since the authors were testing the effect of treatments in a particular direction, one-tailed tests were considered appropriate for the test of mean scores. The consequences of a Type I error, rejecting the null hypothesis when it is in fact true, are thought to have minimum impact on the data analysis.

## B. DECISION TASK

In Chapter III, group decision task characteristics were described as the primary factors driving the determination of group performance. Here the first order of analysis is to determine if in fact such characteristics were represented in this experimental design. From Gallupe, these characteristics were: 1) face validity, 2) supportability, 3) content validity, and 4) external validity.

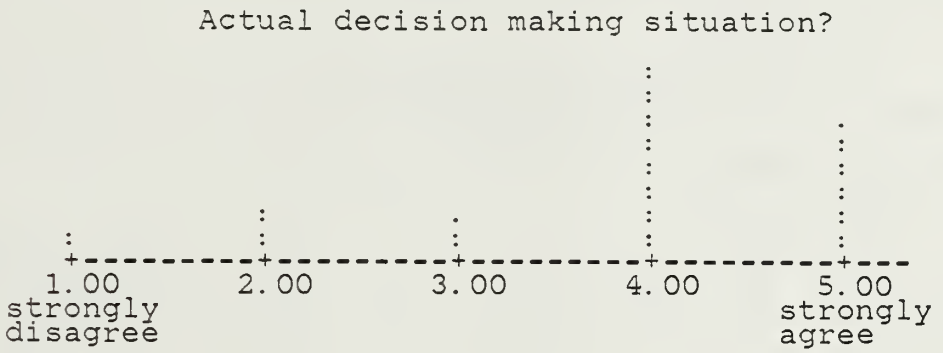
The following text will attempt to prove that each essential characteristic was present, was well represented, and satisfied all requirements necessary to ensure the group decision task employed during this experiment was valid.

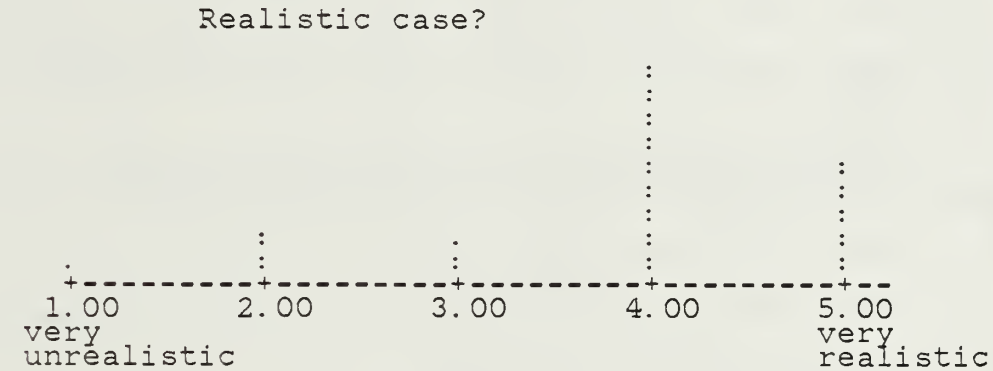
### 1. Face Validity

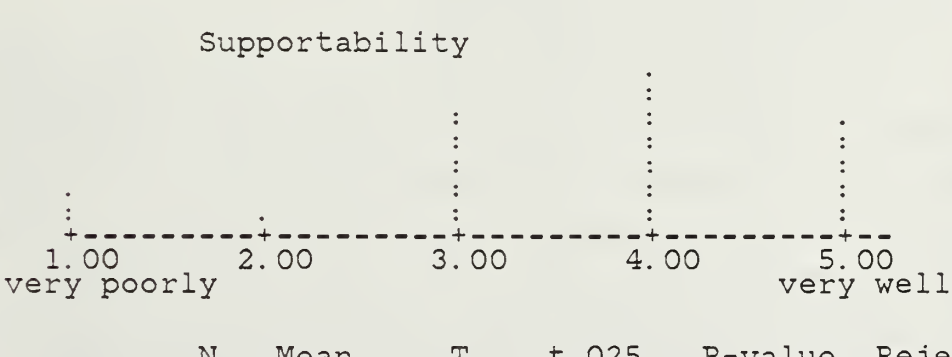
Question #3 was posed to lend insight into face validity. The results indicate the majority of subjects felt the case was somewhat realistic. The null hypothesis tested was the majority of respondents will feel the case was realistic to very realistic. The alternative hypothesis was that the subjects will choose unrealistic to very unrealistic As can be seen in Figure 5.1, the null hypothesis must be rejected.

On the whole, some participants commented on the lack of information they, as managers, felt was essential in the selection process. They believed personal interviews would have been important for determining the candidate's personality, general health, and sex; all elements not as obvious in the case itself. (Note: The determination of sex was possible from the case materials provided. These comments were made by those failing to recognize this possibility.) Likewise, one participant expressed a desire to evaluate candidates along the lines of 'adaptability' and 'growth

potential'. No information, much less any valid means by which to assess such qualifications, were provided in the case study. Performance evaluations were also lacking and their omission cited as significant.




| | N | Mean | T | t.025 | P-value | Reject Ho |
|---|---|---|---|---|---|---|
| actual | 36 | 3.833 | +4.31 | +1.645 | 0.0001 | Yes |
| real | 36 | 3.889 | +5.15 | +1.645 | 0.0000 | Yes |
| support | 36 | 3.667 | +3.49 | +1.645 | 0.0007 | Yes |

Figure 5.1 Decision Task Measures.

2. **Supportability**

The null hypothesis tested was that respondents will choose very poorly to poorly to describe the supportability. The responses to question #4, as shown in Figure 5.1, rejected the null hypothesis. The subjects indicated the case was appropriate for support by the GDSS tool used.

3. **Content Validity**

No questions were posed to highlight any discrepancies in this area and no problems were cited by any of the participants as to the content validity. As such, the assumption was made that the requirement of content validity was met.

4. **External Validity**

To test this result statistically, rejection of the null hypothesis is in order. This hypothesis states that respondents will choose strongly disagree to disagree as to how well this case represented an actual decision-making situation. Figure 5.1 shows such a rejection is in fact appropriate. The majority of subjects responding to the questionnaire chose agree to strongly agree to express how they felt about the case's external validity.

Based on the above, the issue whether Energy International provided a valid group decision task can be resolved. Experimental results show the characteristics of face validity, supportability, content validity, and external validity, were correctly represented in the case, qualifying it as a valid group decision task for testing purposes.

## C. DECISION OUTCOME MEASURES

1. **Decision Quality and Baseline Criteria**

For this experiment, decision quality is equated with the correct answer which was based on experts' choice. Therefore, the measurement of decision quality was simply a matter of determining which group had a greater number of correct answers. As shown in Figure 5.2, four out of six distributed groups came up with the correct selection vice two in the FTF groups.

The number of baseline criteria generated by each group was analyzed using the printouts from the group sessions. The baseline criteria that should have been used to come up with the correct solution were provided with the case. The baseline criteria were: 1) at least 35 years of age, 2) appropriate school/sex (where sex can be derived from information given concerning the size of the school attended), 3) American citizen, 4) Portuguese language ability, 5) at least three years of managerial experience,

and 6) education requirements, i.e. passing grades in both seismology and paleontology. Three criteria, namely age, citizenship, and Portuguese language ability, were provided up front in the candidate summary sheets. Managerial experience, sex, and education criteria could be determined from the information provided in the case.

DISTRIBUTED GROUPS

| Criteria | Group Numbers | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Age | 111 | 111 | 111 | 1 | 111 | 1 |
| School/sex | 1 1 | | | 1 | 1 | 11 |
| American | 111 | 111 | 111 | 1 | 111 | 1 |
| Portuguese | 111 | 111 | 111 | 11 | 111 | 11 |
| Experience | 111 | 1 1 | 11 | 111 | 111 | 111 |
| Education | 11 | 11 | 111 | 1 1 | 1 1 | 1 |
| Total | 655 | 544 | 455 | 325 | 546 | 145 |
| Correct answer: | | | | | | |
| Individual | X* | *X | * | * | * X | XXX |
| Group | Yes | Yes | No | No | Yes | Yes |

X = Came up with the one correct answer
* = Tied for the first place; could not determine one correct answer due to lack of sex discrimination.

FTF GROUPS

| Criteria | Group Numbers | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4* | 5 | 6 |
| Age | 1 | 1 | 1 | 1 | 1 | 1 |
| School/sex | | | 1 | 1 | | 1 |
| American | 1 | 1 | 1 | 1 | 1 | 1 |
| Portuguese | 1 | 1 | 1 | 1 | 1 | 1 |
| Experience | 1 | 1 | | 1 | 1 | 1 |
| Education | 1 | 1 | | 1 | | 1 |
| Total | 5 | 5 | 4 | 6 | 4 | 6 |
| Correct answer: | | | | | | |
| Group | No | Yes | No | No | No | Yes |

* = Group 4 generated all the baseline criteria, but failed to come up with the correct solution because not enough weight difference was given to each candidate who met the criteria.

Figure 5.2 Decision Quality and Baseline Criteria.

To determine whether the individuals groups correctly generated and met the baseline criteria, the rating given to each candidate was carefully scrutinized. This was necessary since some individuals groups came up with the right criteria, but incorrectly applied them to the candidates. Only those correctly applied were credited for having successfully met the baseline criteria. Figure 5.2 displays the results of the analysis.

Of particular interest is the sex criterion. The results indicate that by failing to resolve the sex of the candidates, five participants in the distributed groups tied two candidates for the job. One was the correct candidate and the other was the only female applicant. (One other participant tied the same two candidates, but this was due to mistakes made with another criterion). Three of these individuals helped to determine their groups' correct response. The FTF groups did not evidence the same result when they failed to distinguish the sex of the candidates.

As shown in Figure 5.2, one FTF group (Group #4) successfully generated and met all baseline criteria for selecting a correct candidate. Unfortunately, the group members did not assign enough weight differences between the candidates when they weighed how each candidate met the requirements. As a result, even though they identified all the baseline criteria, they were unable to select the correct candidate.

Secondly, some of the individuals and groups who did not meet all the baseline criteria were able to choose the correct candidate. The weighing strategy employed overrode the baseline criteria requirement. This was possible because these participants created large weight differences among the candidates, so that the criteria they did use were useful selection measures.

## D. DECISION SPEED.

The actual time taken by distributed and non-distributed groups, while deriving a solution, constituted the second area for data analysis. (See Figure 5.3) Recall from Chapter IV that read time and input time composed the total task time for distributed groups. Non-distributed groups were measured using the same technique with an addition of discussion time taken prior to reaching group consensus.

The null hypothesis tested was that the two samples will be comparable and that no statistical significance would exist between them. If this had proven true, nothing could have been said regarding the efficiency of distributed versus non-distributed groups, other than they were found to be comparable.

The read times show a significant difference does exist between FTF and distributed groups. FTF groups spent less time in the read phase than did distributed groups. On the other hand, FTF groups spent more time in the input phase and, therefore, expended more time overall deriving a solution.

The difference between distributed and non-distributed total time (manminutes) occurred because in the non-distributed mode three individuals were required to reach a consensus prior to inputting a response into the GDSS and continuing on with the experiment. Just how much time was spent in this FTF setting, can be seen by comparing mean times between the two modes. FTF groups decision speed was significantly slower than the distributed groups, indicating FTF groups were much less efficient.

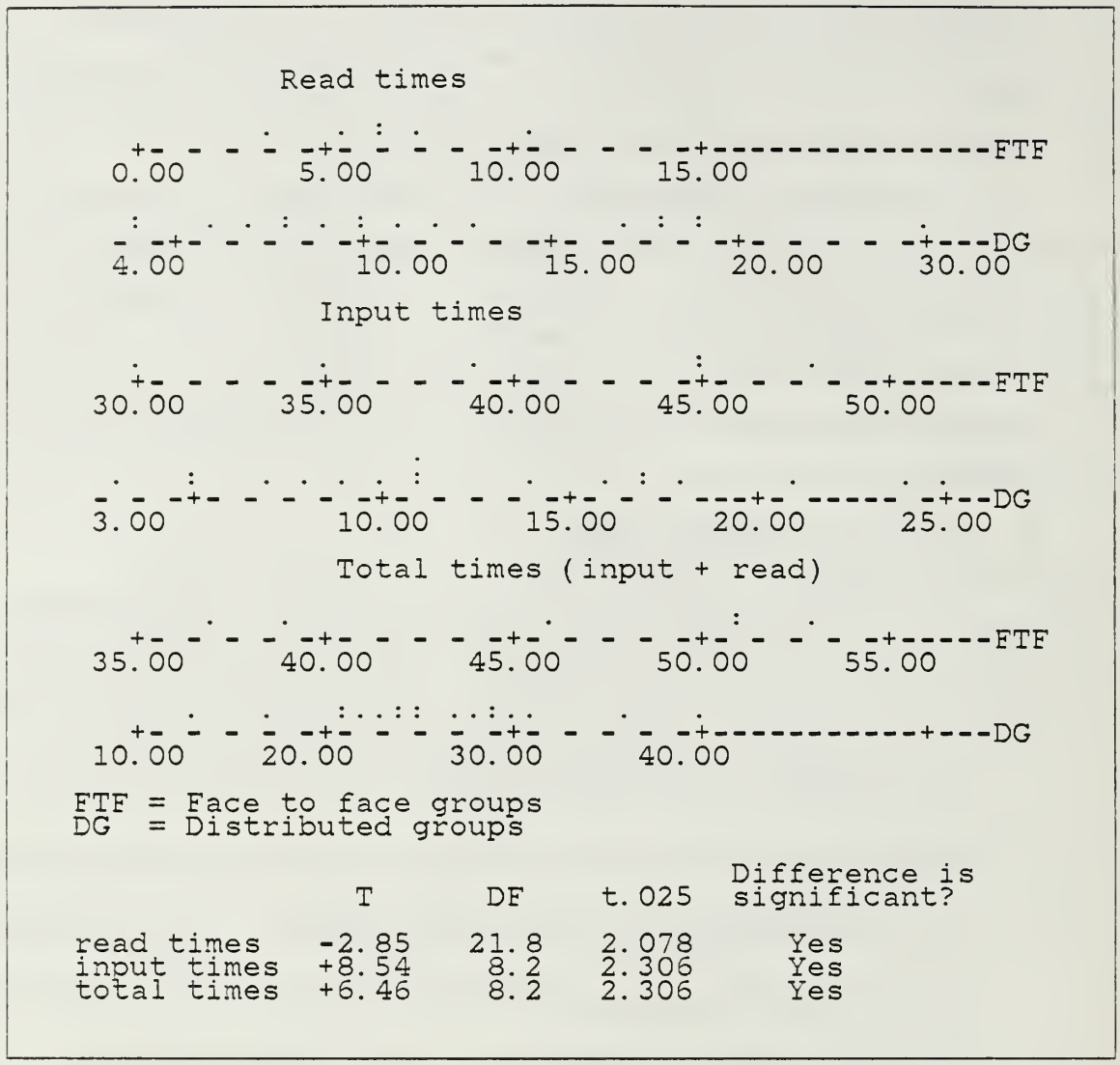
## E. DECISION SATISFACTION

Two satisfaction variables, based on the answers in the questionnaire, were measured to establish the decision satisfaction factors: 1) satisfaction with the individual group solution, and 2) satisfaction with the group results. The t-statistical test results for both groups are shown in Figure 5.4. The null hypotheses are:

- Ho1: Members of both groups will feel they have derived a mediocre to very poor solution.
- Ho2: Members of both groups will feel indifferent to very unsatisfied with their group's result.
- Ho3: Distributed group members will feel indifferent to very unsatisfied with their individual result.
- Ho4: There would be no perception difference between groups concerning how good a solution they derived.
- Ho5 There would be no difference in the satisfaction level of both groups concerning their group result.
- Ho6: Distributed group members would feel equally satisfied with their individual result and group result.

### 1. Perception About Individual/Group Solution

The questions: "All in all, how good a solution did you devise?" and "How good a solution did your group devise?" were administered to individuals in the distributed groups and FTF groups respectively. These questions were designed to determine participants' perceptions regarding their individual/group solution when compared to the experts' solution. The correct solution was given to all participants before they answered the questionnaire.




FTF = Face to face groups
DG = Distributed groups

| | T | DF | t.025 | Difference is significant? |
|---|---|---|---|---|
| read times | -2.85 | 21.8 | 2.078 | Yes |
| input times | +8.54 | 8.2 | 2.306 | Yes |
| total times | +6.46 | 8.2 | 2.306 | Yes |

Figure 5.3 Decision Speed.

As shown in Figure 5.4, both group members felt rather strongly that they produced a good to very good solution regardless of whether it agreed with the experts' answer. The null hypothesis (Ho1) was firmly rejected. Taped comments indicate they believe the candidate they chose was either as good as the experts' choice or better. For the FTF groups, this strong belief seemed to be based on the fact candidate selection had been via group consensus.

Although the FTF groups' mean score was higher, the difference between the mean scores of two settings was not significant enough to state there is a difference in perception between the two groups.

### 2. Satisfaction with Individual/Group Results

To establish participants' satisfaction with the final results derived from their inputs, three questions were asked:

- How satisfied are you with the final result derived from your group result? (DG).
- How satisfied are you with the group result? (DG).
- How satisfied are you with the final result derived from your group result? (FTF).

The responses are shown in Figure 5.4.

Participants in the distributed groups were satisfied with the final result (i.result) derived from their individual inputs. Yet, half of them were less satisfied with their group result (d.result). They believed, as individuals, they made a good selection, but the group as a whole did not. On the other hand, FTF groups were relatively satisfied with their group results (g.result), in spite of the fact more of them were incorrect.

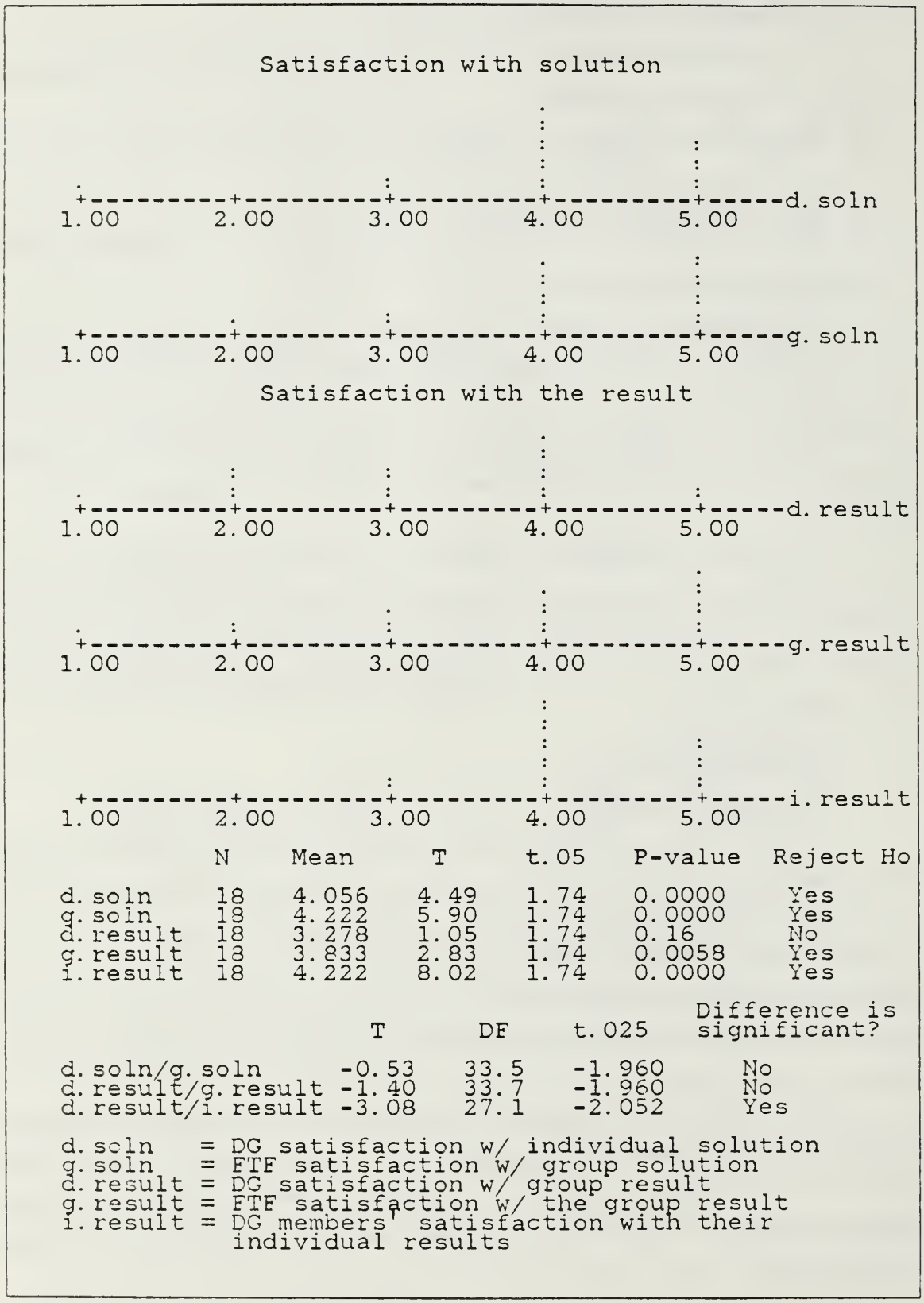
The difference in satisfaction level between the two groups (d.result/g.result) is not strong enough to state clearly that members of one group were more satisfied than the other about their group result. However, within the distributed group, there is a significant difference in the satisfaction level between the individual effort and group effort (d.result/i.result).

## F. OTHER VARIABLES

### 1. Originality/Creativity

"Other" criteria, in addition to the baseline criteria, were analyzed to further distinguish between the two groups. A criterion was measured as "other" when it was not applied correctly and when it did not overlap with the baseline criteria. For example, several individuals mentioned sex as a criterion, but did not get credit for it as a baseline criterion because they failed to figure out the sex of the candidates. Instead, they were credited for having derived an "other" criterion. Results are shown in Figure 5.5.

The distribution of the number of baseline, other, and total criteria is shown in Figure 5.5. Compared to the FTF groups values, the distributed group mean values were lower for all three. Nevertheless, the differences in the mean values are not significant enough to reject the null hypothesis that there are no differences between the two groups.




| | N | Mean | T | t.05 | P-value | Reject Ho |
|---|---|---|---|---|---|---|
| d.soln | 18 | 4.056 | 4.49 | 1.74 | 0.0000 | Yes |
| g.soln | 18 | 4.222 | 5.90 | 1.74 | 0.0000 | Yes |
| d.result | 18 | 3.278 | 1.05 | 1.74 | 0.16 | No |
| g.result | 18 | 3.833 | 2.83 | 1.74 | 0.0058 | Yes |
| i.result | 18 | 4.222 | 8.02 | 1.74 | 0.0000 | Yes |

| | T | DF | t.025 | Difference is significant? |
|---|---|---|---|---|
| d.soln/g.soln | -0.53 | 33.5 | -1.960 | No |
| d.result/g.result | -1.40 | 33.7 | -1.960 | No |
| d.result/i.result | -3.08 | 27.1 | -2.052 | Yes |

d.soln = DG satisfaction w/ individual solution
g.soln = FTF satisfaction w/ group solution
d.result = DG satisfaction w/ group result
g.result = FTF satisfaction w/ the group result
i.result = DG members' satisfaction with their individual results

Figure 5.4 Decision Satisfaction.

DISTRIBUTED GROUPS

| Criteria | Group Numbers | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | | 6 | | | Mean |
| Baseline | 6 | 5 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 3 | 2 | 5 | 5 | 4 | 6 | 1 | 4 | 5 | 4.33 |
| Other | 0 | 1 | 0 | 1 | 0 | 2 | 0 | 1 | 1 | 0 | 4 | 2 | 1 | 2 | 0 | 3 | 0 | 2 | 1.11 |
| Total | 6 | 6 | 5 | 6 | 4 | 6 | 4 | 6 | 6 | 3 | 6 | 7 | 6 | 6 | 6 | 4 | 4 | 7 | 5.44 |

NON-DISTRIBUTED GROUPS

| Criteria | Group Numbers | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | Mean |
| Baseline | 5 | 5 | 4 | 6 | 4 | 6 | 5.00 |
| Other | 0 | 3 | 3 | 1 | 2 | 4 | 2.17 |
| Total | 5 | 8 | 7 | 7 | 6 | 10 | 7.17 |

| | T | DF | T.025 | Difference is significant? |
|---|---|---|---|---|
| DG/FTF baseline | -1.41 | 12.5 | -2.170 | No |
| DG/FTF other | -1.59 | 7.3 | -2.326 | No |

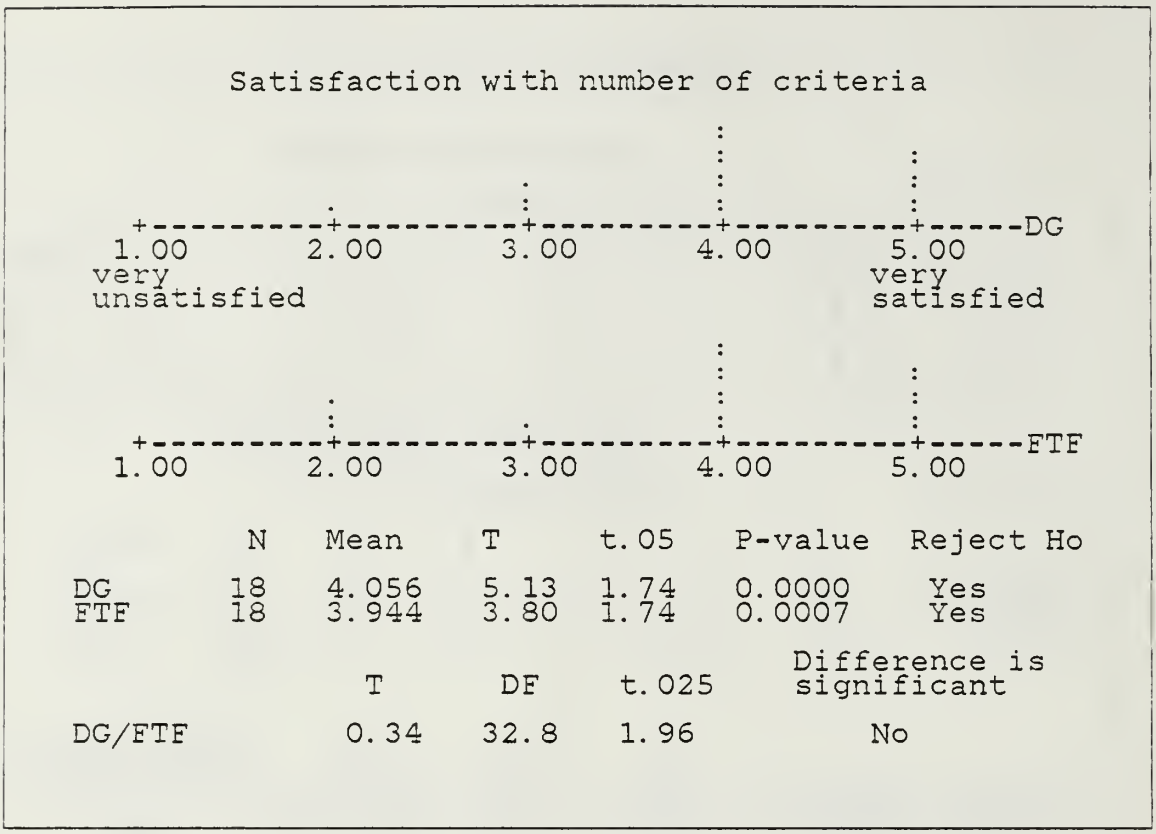
Figure 5.5 Total Number of Criteria.

2. **Satisfaction with the Number of Criteria Generated**

The same question, "How satisfied are you with the number of criteria that you identified?" was given to both groups. The null hypotheses are:

1) no difference in satisfaction level between the two groups will be evident, and
2) both groups will be indifferent to very unsatisfied about the number of criteria they generated.

As is evident in Figure 5.6, the majority of both group members were satisfied to very satisfied. The distributed group members were less unsatisfied with the criteria they generated; even though, the same number of both group members stated they were either satisfied to very satisfied. The difference between the satisfaction level of distributed groups and non-distributed groups was not significant.




| | N | Mean | T | t.05 | P-value | Reject Ho |
|---|---|---|---|---|---|---|
| DG | 18 | 4.056 | 5.13 | 1.74 | 0.0000 | Yes |
| FTF | 18 | 3.944 | 3.80 | 1.74 | 0.0007 | Yes |

| | T | DF | t.025 | Difference is significant |
|---|---|---|---|---|
| DG/FTF | 0.34 | 32.8 | 1.96 | No |

Figure 5.6 Criteria.

3. Settings

Given that both groups 1) used the same computer-mediated tool, 2) worked on the same intellective task requiring group members to work in a cooperative environment, and 3) had a case with an answer that could be derived individually without a group effort, the authors presumed there would be no preference for either FTF or distributed settings. As indicated in Figure 5.7, this was not a correct premise. The null hypothesis was that participants will have no preference for either a non-distributed setting or a distributed setting. Although for the distributed groups the sample mean was slightly over the population mean of three, this was not significant enough to reject the first null hypothesis. However, FTF group participants did significantly prefer the non-distributed setting.

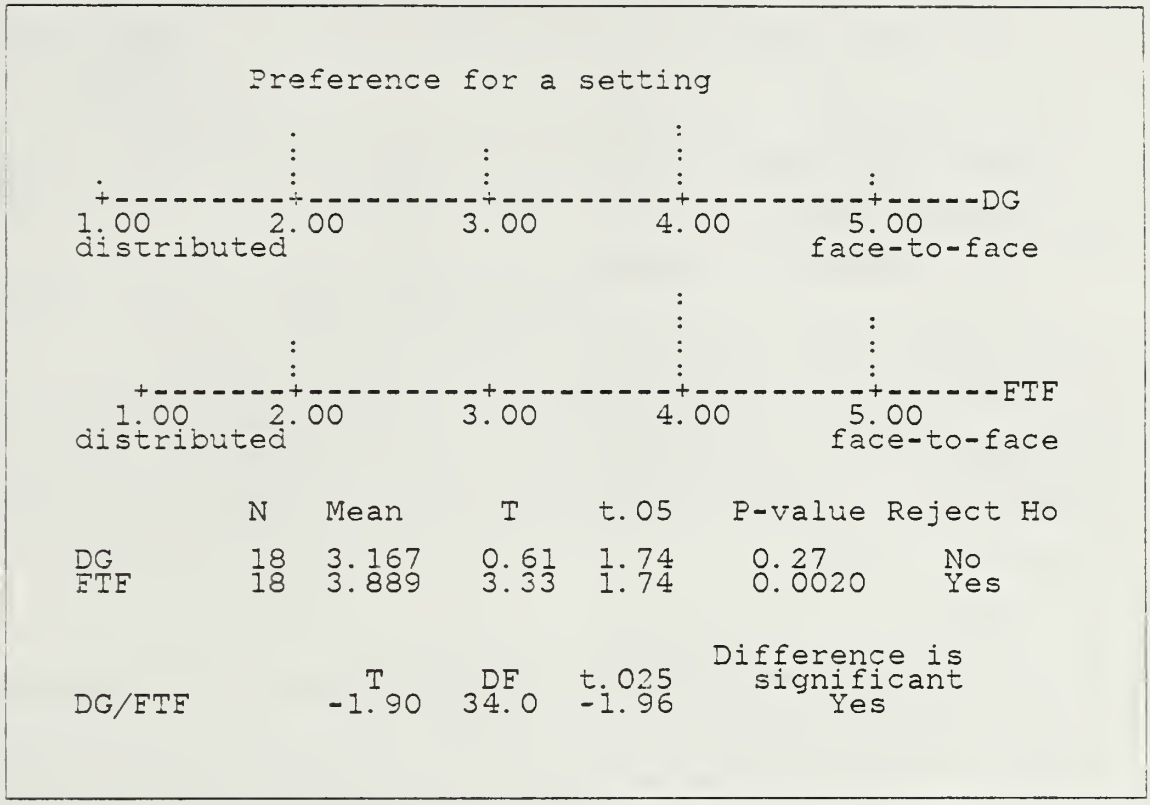



Figure 5.7 Setting.

## G. SUMMARY

The three hypotheses, various variables, and methods of analysis were presented in this chapter. The authors considered validation of the selected case a very important step. For this reason, a section was devoted to the validity of the task. Each of the hypotheses: decision quality, decision speed, and decision satisfaction were introduced with their supporting data and methods of measurement. These were deemed important in determining the differences between the two settings. "Other" variables were also measured to further define the differences between the two groups. The analysis of the data shown here and the conclusions drawn from them are presented in the next chapter.

# VI. CONCLUSIONS

The authors conducted the experimental study on the premise that recent developments in GDSS tools would increase the efficiency and effectiveness of group decision-making and problem solving activities. Based on this premise, the goal of the experiment was to determine in which setting, distributed or face-to-face, a GDSS tool would be more effective.

The framework for the experiment was primarily based on Gallupe's four issues: the nature of the group decision task, the design of the GDSS, the subjects and setting, and the measureable variables. These issues and their application to the test were discussed in detail in Chapters III and IV. In Chapter V, the three major hypotheses and related questions were presented, along with the results from the experiment, to either support or disprove the hypotheses. This chapter presents a comprehensive picture of the results.

## A. TASK

As mentioned previously, the decision task selected for the groups strongly affects the group performance. Using McGrath's Task Circumplex as a model, we chose an intellective task with a correct answer. According to McGrath an intellective task is generally conceptual and requires the cooperation of the group members to be solved successfully.

The task characteristics of face validity, supportability, content validity, and external validity were also carefully taken into consideration. The participants' perceptions of the validity of these characteristics were extracted via the questionnaire. As shown below, the majority of participants confirmed the task selected was realistic, supportable by Co-oP, and relevant.

1) The majority of participants judged the case study to be realistic to very realistic.

2) The majority indicated the GDSS tool used supported the case well to very well.

3) Since the information provided in the case was consistent and correct, the authors assumed content was valid.

4) The majority of responses ranged from agree to strongly agree on external validity.

## B. DECISION OUTCOME MEASURES

The measures chosen to determine the differences between the two settings were the decision outcome variables of decision quality, decision speed, and satisfaction with the final decision. The experimental results of these variables are discussed in the following pages.

### 1. Decision Quality

The number of groups with the correct answer in each setting was counted to see which mode was more effective. Four out of six distributed groups versus two out of six FTF groups had the correct solution. Since the distributed groups scored 50% better, FTF groups were clearly less effective.

Although FTF groups generated more baseline criteria, this had no effect on the quality of the final result. This was basically due to the weighing strategy used by the groups. The group results can be skewed depending on the point spread difference given to each candidate as to how well he she met the criteria. Small variations failed to distinguish clearly between the candidates.

### 2. Decision Speed

The read time, input time, and the resulting totals were analyzed to demonstrate that distributed groups require less manminutes to reach the solution. Results are:

1) FTF groups spent less time in reading the case study.

2) FTF groups spent more time during the interactive phase. This includes discussion time, prior to reaching a group consensus, and actual input time.

3) FTF groups spent more total manminutes during the problem-solving process. On the average, each individual member of the FTF groups spent 46.2 minutes; whereas, individual members of distributed groups spent 25.8 minutes in the process.

Distributed groups were more time efficient during the interactive phase and during the total decision making process. This is to be expected, since individuals in distributed groups could make inputs into the final group decision without having to discuss and reach a group consensus.

### 3. Decision Satisfaction

Two variables, satisfaction with individual group solutions and satisfaction with the group results were measured to compare the decision satisfaction level between the two groups. Analysis of data indicates:

1) Both group members were satisfied with their individual group solution.

2) Members of distributed groups were satisfied to very satisfied with their final individual result.

3) Only 50% of distributed group members were satisfied with their final group results; whereas, 67% of the FTF group members were satisfied.

4) Not enough difference is evident to state clearly whether members of one setting were more satisfied than the members of the other.

Distributed groups had better decision quality and faster decision speed than the FTF groups during the decision making process. The conclusion is that for the intellective task chosen, subjects in the distributed groups generally utilized the GDSS tool more effectively and efficiently. However, the question as to whether the subjects of one group were more satisfied with their solutions and final group results than the subjects of the other cannot be answered conclusively here.

## C. OTHER VARIABLES

The GDSS tool used in the experiment required, for its problem definition phase, two types of inputs from the decision makers before the problem solving phase. The inputs are the alternatives and criteria. The chauffeur used the data from the candidate summary sheets to input the list of alternatives, which were the names of the candidates. The group members formulated their own criteria during interaction with the chauffeur. To gain insight into the impact of the subjects generating their own criteria, several questions were asked on the questionnaire.

### 1. Originality/Creativity

The possibility that FTF groups would generate a greater number of original and creative criteria, due to the exchange of ideas present in a non-distributed setting, was explored in this section. The originality/creativity variable was measured based on the total number of criteria generated by each group. This total included the baseline criteria and any other criteria mentioned by the participants. The conclusions are:

1) No determination can be made as to which group generated and met the baseline criteria more often.

2) No determination can be made as to which group formulated more creative and original criteria.

### 2. Satisfaction with Criteria Generated

Questions were also asked to see how satisfied the participants were with the number of criteria they generated. No difference in the satisfaction level between the two groups was indicated by the data. Moreover, a majority of both group members felt satisfied to very satisfied with the number of criteria they developed.

3. Settings

Since this experiment was conducted using two distinct settings, the participants were asked which setting they preferred. The premise was that there would be no preference for either setting. This held true for the distributed groups. On the other hand, FTF groups significantly preferred the non-distributed setting. This preference may be due to the fact that people do prefer face-to-face communications. Yet, because no stong preference for FTF setting was observed in distributed group members, the issue is not clear cut.

## D. SUMMARY

The goal of this experiment was to determine in which setting a GDSS tool would prove more useful. Since this is only a preliminary effort into this as yet unexplored area, no definite conclusion can be drawn. Nevertheless, two out of the three decision outcome measures, decision quality and decision speed, showed distributed in time space setting was more effective and efficient. Better and faster decisions can be achieved in a distributed setting. This may be the result of the problems that inhibit the FTF interacting groups as mentioned in Chapter I.

The additional research questions asked to gain insight into the impact of a GDSS tool on the decision making process resulted in no firm findings. Specifically, no measurable differences between the two groups were observed in creativity/originality and satisfaction with the number of criteria generated. However, as far as the setting was concerned, a preference for FTF setting by those in non-distributed setting was noted. Additional studies are recommended to further quantify the results presented in this paper.

# APPENDIX A
# ENERGY INTERNATIONAL CASE STUDY

You are one of the General Mangers of Energy International, a young, medium-sized, growing organization. The prime mission of E. I. is to locate and develop mineral claims (copper, uranium, cobalt, etc.).

The company's business has grown very rapidly, especially in South America, where your organization has been made welcome by the government. In a recent meeting, the board of directors decided to develop a new property near Fortaleza, in northeastern Brazil. This operation will include both mining and milling production.

The date is October 1, 1986. You have come from your respective plants in different locations. This is the initial session of your annual meeting. Your first order of business today is to select a new General Manger for the Brazilian plant from among the candidates on the attached list.

Fortaleza, Brazil has a hot climate, one railroad, a scheduled airline, a favorable balance of trade, a feudal attitude toward women, considerable unemployment, a low education level, a low literacy rate, and a strongly nationalistic regime.

The government has ruled that the company must employ Brazilians in all posts except that of manager. It has also installed an offical inspector, who will make a monthly report which must be countersigned by the General Manager. None of the government inspectors and company's employees or staff can read or write any language but Portuguese.

The General Manager should have at least three years of experience as a manager in charge of a mining operation, be an American citizen, and be a Fellow of the Institute of Mineralogy.

Fellowship in the Institute of Mineralogy can be obtained by those over 35 years of age who have otherwise qualified for General Membership in the Institute. To qualify for General Membership, a candidate must have a degree in mineralogy with a passing grade in paleontology and seismology.

There are a number of schools offering degrees in mineralogy. The smaller universities require three, the larger four, special subjects as a part of their graduation requirements. The smallest is a women's university. The largest univeristy, the New York School of Mines, requires geology, paleontology, geophysics, and seismology for

graduation. The New Mexico Institute of Earth Sciences requires geology, seismology, and paleontolgy, in addition to the usual courses. The Massachusetts Institute of Sciences requires geology, seismology, oceanography, and paleontology. St. Francis University, which is not the smallest school, requires paleontology, geophysics, and oceanography.

Using the above information and attached candidate summary sheets, develop criteria that you would use to select the candidate, and based on them select the best candidate for the job.

# APPENDIX B
## QUESTIONNAIRE

PLEASE ANSWER THE FOLLOWING QUESTIONS AFTER THE END OF YOUR SESSION. WHERE APPLICABLE, JUST CIRCLE THE NUMBER THAT BEST MATCHES YOUR RESPONSE. THANK-YOU FOR YOUR HELP.

I. CASE

1. IMMEDIATELY AFTER READING THE CASE STUDY, WAS THE CORRECT CANDIDATE INTUITIVELY OBVIOUS TO YOU?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| COMPLETELY UNOBVIOUS | SOMEWHAT UNOBVIOUS | | SOMEWHAT OBVIOUS | COMPLETEL OBVIOUS |

2. WOULD YOU SAY THIS CASE STUDY CAN BE AN EXAMPLE OF AN ACTUAL DECISION MAKING SITUATION IN AN ORGANIZATION?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | | AGREE | STRONGLY AGREE |

3. DOES THIS CASE STUDY APPEAR TO BE REALISTIC TO YOU?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| VERY UNREALISTIC | UNREALISTIC | | REALISTIC | VERY REALISTIC |

4. DOES THIS CASE STUDY LEND ITSELF TO SUPPORT BY CO-OP?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| VERY POORLY | POORLY | | WELL | VERY WELL |

II. CRITERIA

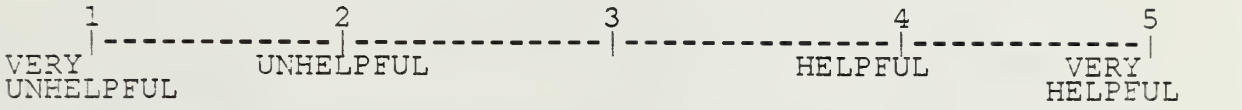
5. HOW SATISFIED ARE YOU WITH THE NUMBER OF CRITERIA THAT YOU IDENTIFIED?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| VERY UNSATISFIED | UNSATISFIED | | SATISFIED | VERY SATISFIED |

6. PUTTING WEIGHTS ON YOUR CRITERIA HELPED YOU IN YOUR DECISION MAKING PROCESS?

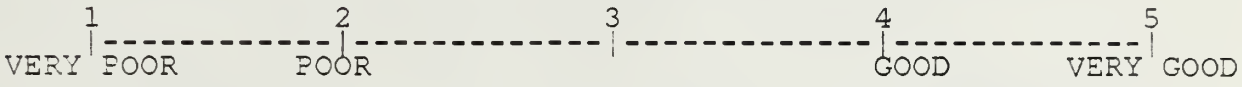
| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | | AGREE | STRONGLY AGREE |

7. TO WHAT EXTENT DO YOU FEEL CO-OP HELPED YOU IN FORMALIZING YOUR THOUGHTS?

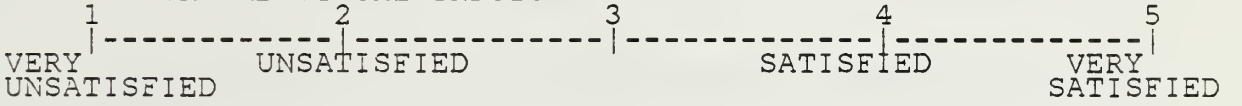



III. RESULTS (DISTRIBUTED GROUP)

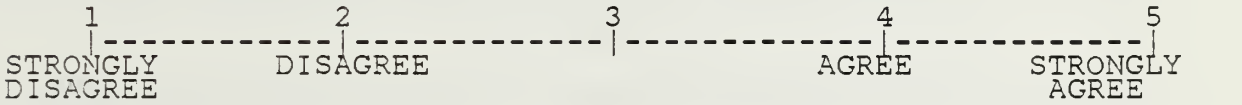
8. ALL IN ALL, HOW GOOD A SOLUTION DID YOU DEVISE?



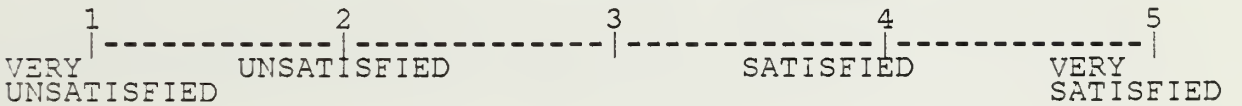

9. HOW SATISFIED ARE YOU WITH THE FINAL RESULT DERIVED FROM YOUR INDIVIDUAL INPUTS?




10. THIS CASE IS/WOULD BE BETTER SOLVED IN FACE-TO-FACE SETTING VICE A DISTRIBUTED SETTING.

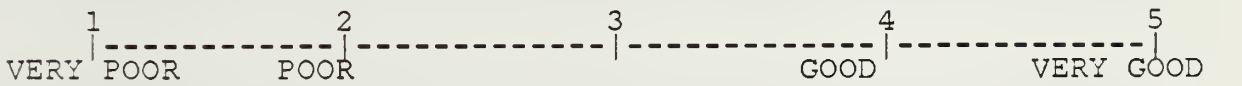



11. HOW SATISFIED ARE YOU WITH THE GROUP RESULT? (ANSWER AFTER RECEIVING YOUR GROUP'S RESULT).

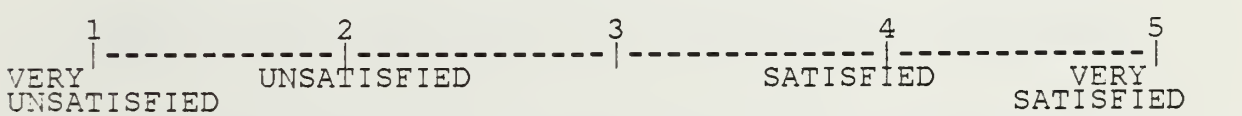



IV. RESULTS (NON-DISTRIBUTED GROUP)

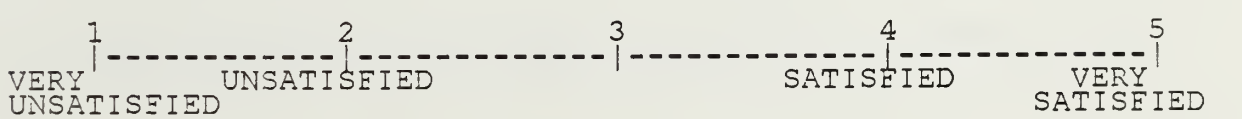
12. HOW GOOD A SOLUTION DID YOUR GROUP DEVISE?




13. HOW SATISFIED ARE YOU WITH THE DECISION MAKING PROCESS THAT YOUR GROUP UNDERWENT TO DEVELOP THE SOLUTION?




14. HOW SATISFIED ARE YOU WITH THE FINAL RESULT DERIVED FROM YOUR GROUP INPUTS?



15. DO YOU FEEL YOUR GROUP ACCEPTED YOUR CONTRIBUTIONS TO SOLVING THE PROBLEM?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| COMPLETELY UNACCEPTED | SOMEWHAT UNACCEPTED | | SOMEWHAT ACCEPTED | COMPLETELY ACCEPTED |

16. DO YOU THINK EVERYONE HAD AN EQUAL CHANCE TO BE HEARD IN YOUR GROUP?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| COMPLETELY UNEQUAL | SOMEWHAT UNEQUAL | | SOMEWHAT EQUAL | COMPLETELY EQUAL |

17. THIS CASE IS/WOULD BE BETTER SOLVED IN A DISTRIBUTED SETTING VERSUS FACE-TO-FACE SETTING.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | | AGREE | STRONGLY AGREE |

V. OVERALL IMPRESSION

18. WHAT FACTOR, IF ANY, WOULD YOU SAY INHIBITED AND/OR ENCOURAGED YOUR GENERATION OF INPUTS/

19. WAS CO-OP USER FRIENDLY?

20. IN WHAT KIND OF DECISION MAKING SITUATION WOULD YOU FIND CO-OP MOST USEFUL?

COMMENTS:

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